Space Weather Technical Forecast

Issued on Sunday, 30 July 2023 at 13:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: S1/Moderate Radiation Storm gradually easing. R1-R2 Blackouts likely throughout. G1-G2 Minor/Moderate storms possible 01 Aug with CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with two M-class flares observed. Strongest flare was M1.8 at 30/0822 UTC (a double peaked flare) from AR3390 in the southeast. This is a small region, but with trailer set amongst faculae that perhaps have hidden complexity due to its oblique viewing angle. The other M1.4 flare was observed from AR3880 in the southern centre disc, peaking at 29/1624 UTC. This is a moderately sized region, consisting of a number of small umbra containing spots but with a relatively simple bipolar structure. There are eleven spots in total on the disc, however the only other region currently of note is AR3386. This has remained stable, but continued to show slow growth including the development of two weak mixed polarity (delta spot) regions within its intermediate spots.

No Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The onset of fast winds from CH30/+ was observed, although this feature is largely obscured in SDO imagery. This resulted in background winds of below 400 km/s increasing from 29/2000 UTC to become elevated at just over 500km/s. Density remained below or near average, but did show a very slight rising trend from 30/1200-2000 UTC ahead of the onset of fast winds. The total interplanetary magnetic field (IMF), Bt, remained weak to moderate, peaking near 9nT around 29/2330 UTC before declining again. The north-south component, Bz, had periods of northward and southward orientated field, peaking near +9 nT around 29/2315 UTC, then becoming predominately negative from 30/0230 UTC, with minimum -8nT. Phi angle was predominantly positive (away from the Sun), but showed one erratic rotation through negative and back to positive from 29/2000 UTC to 30/0400 UTC. Geomagnetic activity remained Quiet to Unsettled.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux persisted above the S1/Minor Radiation Storm level, bit with a declining trend, falling from 96 pfu at the start of the period to 20 pfu by 30/1100 UTC. This enhancement was due to the far-side eruption on 28 Jul and had peaked at S2 on 28 Jul. GOES16 high energy (greater than 2MeV) electron flux was initially moderate and very briefly peaking at high levels reaching 1210 pfu at 29/1445 UTC. The observed fluxed dropped out to background after 29/2030 UTC due to the onset of the HSS. The associated 24-hour integrated fluence remained below the Active level (1e8 total pfu) and reached 2.68e7 total pfu at 30/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely to continue with further M-flares. These most likely from AR3380 in just west of the south-centre disc or AR3386 in the northeast.

Solar Wind / Geomagnetic Activity: CME from a filament eruption on 28 Jul is forecast to arrive 01/1000 +/- 9 hours. Otherwise current fast winds are expected to ease day 2 (31 Jul) onward with no further coronal hole source enhancements indicated. Geomagnetic activity is

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expected to be Quiet with Unsettled intervals, with a chance of Active day 1 (30 Jul). The CME arrival is expected to give Active to G1 Minor Storms and a chance of G2 Moderate Storm intervals day 3 (01 Jul). These conditions perhaps continuing into day 4 (02 Aug) before easing to be mainly Quiet by the end of the period.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to gradually, but erratically ease through the period, likely falling below the S1 level later on day 1 (30 Jul) or perhaps early day 2 (31 Jul). There is a chance of a further enhancement to S1 with the CME arrival on day 3 (01 Aug), before returning to background. There is a very slight chance of further enhancement from any other notable flares that occur. The high energy electron flux (greater than 10 MeV) is expected to continue at Background to Moderate levels, but with a chance of brief enhancement to High on day 1 or 2 (30 or 31 Jul) before likely dropping out with the arrival of the CME on day 3 (01 Aug). The associated fluence expected to remain below the Active threshold (1e8 total pfu).

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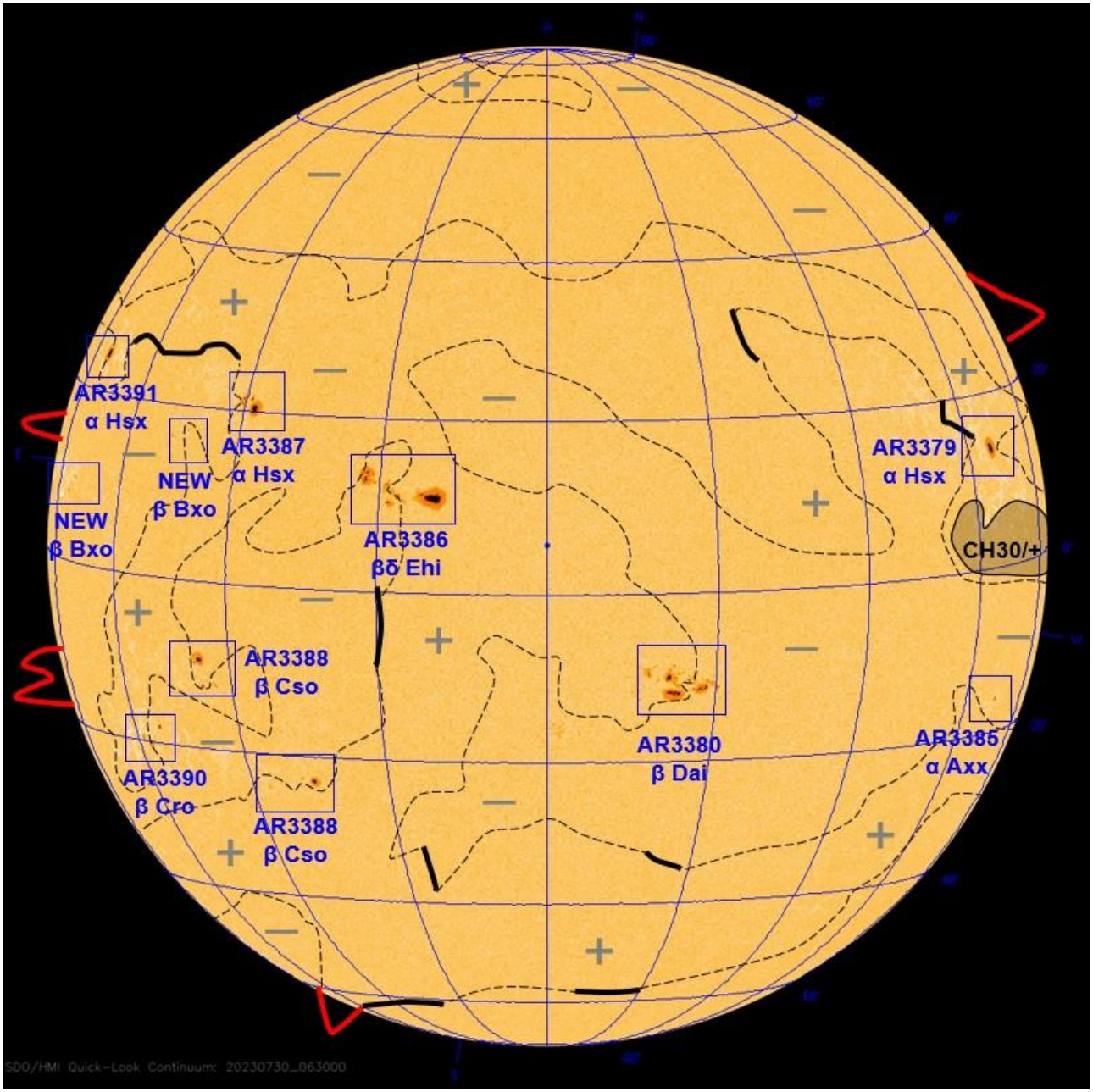
Figure 1. Solar Analysis Valid 30/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one Earth-directed CME, due to the filament eruption from the northeast quadrant on 29 Jul. This is currently forecast to arrive at 01/1000 UTC +/- 9 hours, however recent faster solar winds than indicated in models suggest the potential for an earlier arrival rather than a later one.

Current solar winds have become enhanced, likely due to the arrival of the fast wind from an obscured coronal hole, CH30/+. This can best be seen on SDO aia-193 imagery, when it was positioned in the centre disc (early on 26 Jul). Slightly elevated winds have been observed, near 500km/s, however these are expected to gradually ease later day 1 and during day 2 (30-31 Jul). No further enhancements are then indicted besides the anticipated CME arrival.

Geomagnetic activity is expected to be Quiet with Unsettled intervals, with a chance of Active with the current fast wind on day 1 (30 Jul). The CME arrival, most likely early day 3 (01 Aug) is expected to give Active to G1 Minor Storms and a chance of G2 Moderate Storm intervals. These conditions perhaps continuing into day 4 (02 Aug) before easing to be mainly Quiet by the end of the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	60	20
Strong	G3	No	1	5	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/0550	Partial Halo	Filament Eruption	NE	505 km/s	01/1000 UTC	Nil.

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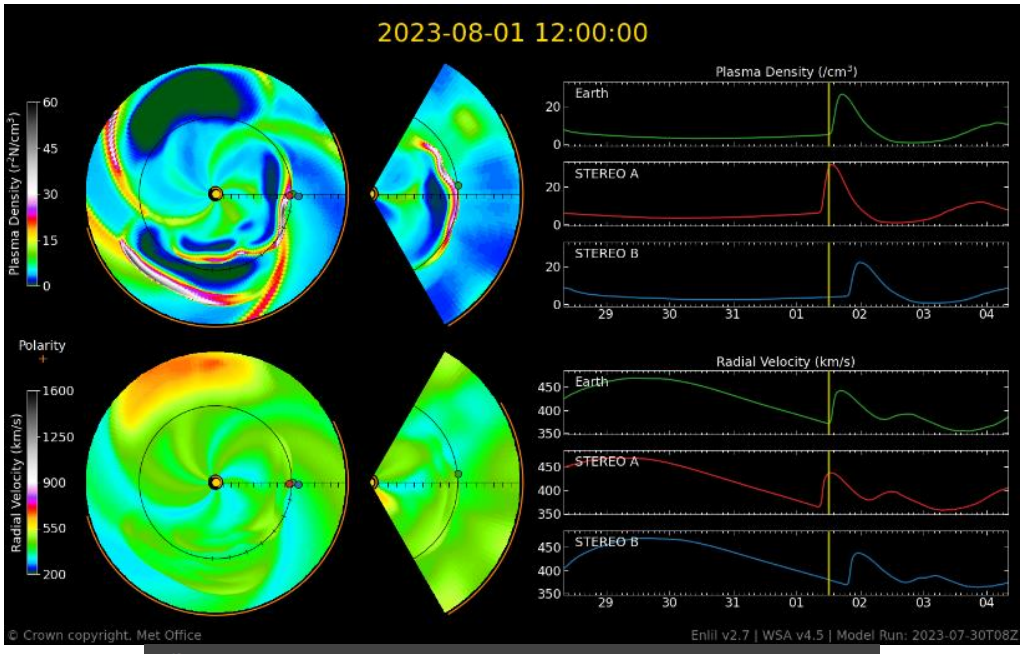
Figure 2: Enlil showing likely arrival of CME on 01 Aug with ensemble below



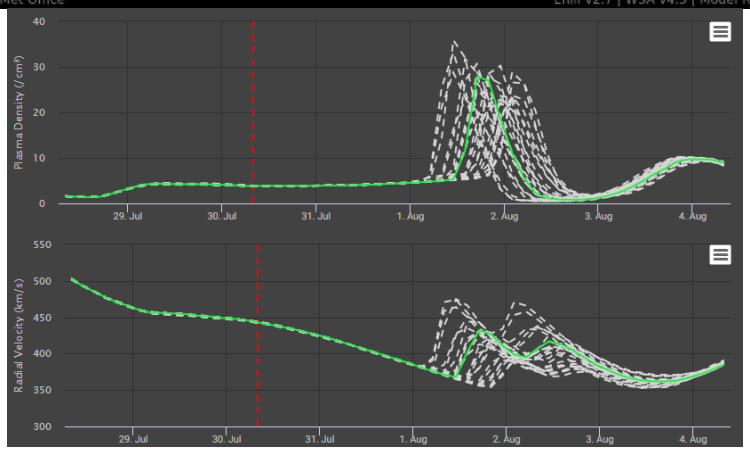
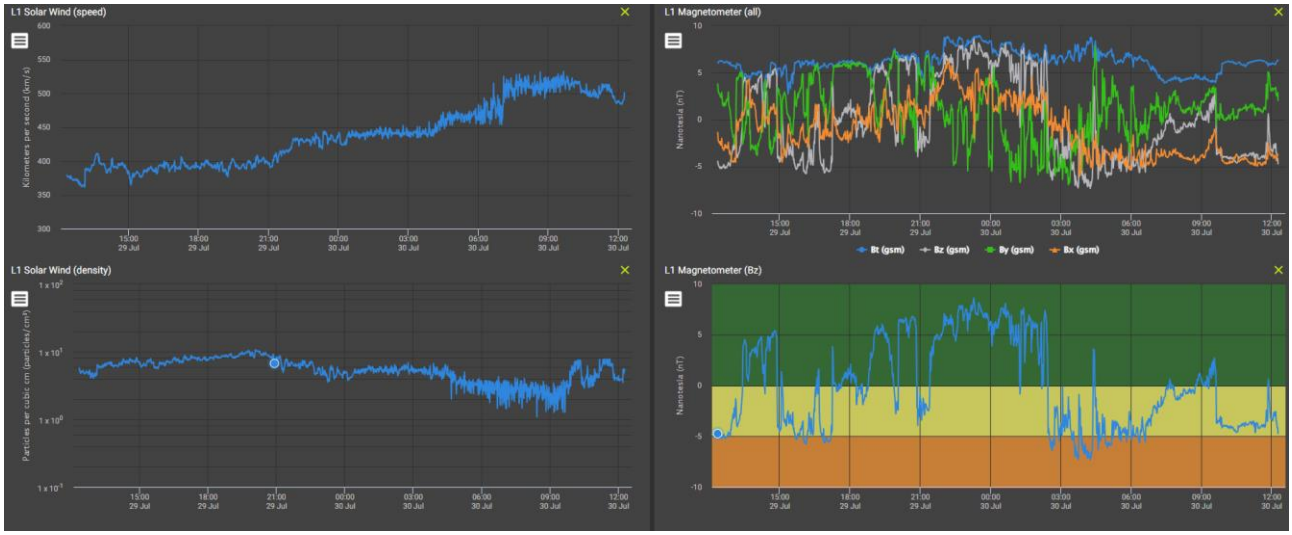


Figure 2: Current solar winds showing fast wind enhancement of CH30



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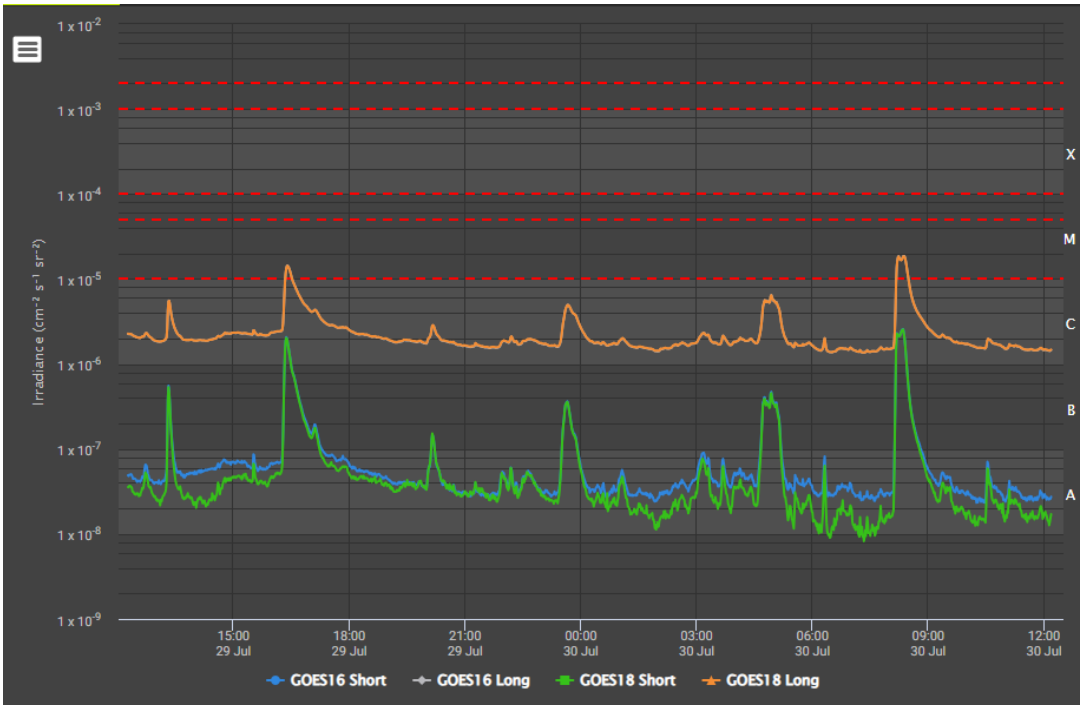
Radio Blackouts - X-Ray Flares:

Current Moderate activity is expected to continue with eleven regions currently on the Earth-facing disc, with further M-class flares likely. Despite its relative simple appearance AR3390 in the southeast has been the most active of the regions in the last 24 hours, with a peak M1.8 flare, and perhaps has more complexity to reveal as it moves into a less oblique viewing angle.

AR3380, is a moderately sized region just east of the central southern disc and has also been a source of a recent M-flare. This has continued to show slow growth in the penumbral extent of spots to the north of what was its original main umbral region, however it remains a simple bipolar structure. AR3386 in the northeast has seen both a consolidation of intermediate spots, and also the development of a small delta spot within them. Further growth is possible in either region, giving a likelihood of M-flares. The other regions remain small and simpler, generally showing no growth or gradually declining.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16-18 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

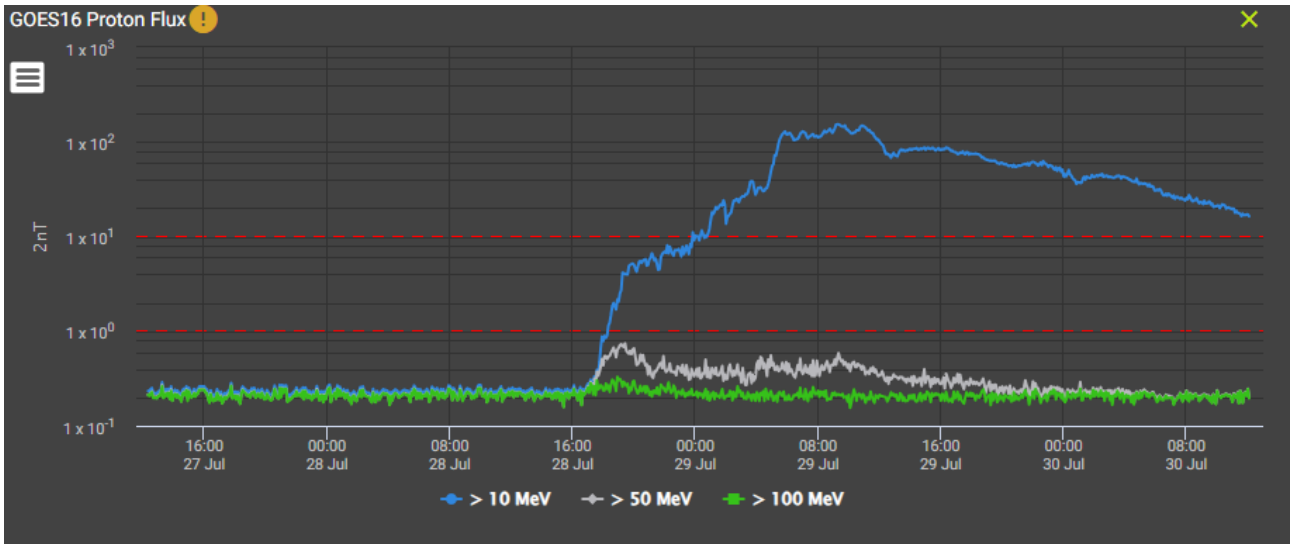
High energy proton flux has gradually eased, but persisted at the S1/Minor Storm level through the last 24 hours. This enhancement was from the large far-sided eruption of AR3376 on 28 Jul, and peaked at S2 early on 29 Jul.

S1 Minor Storm is expected to continue erratically declining day 1 (30 Jul) with a chance of persisting into day 2 (31 Jul). The arrival of the expected CME on day 3 (01 Aug) has a slight chance to bring a brief re-enhancement to S1 levels before a more general decrease towards background is likely to follow into day 4 (02 Aug).

There is also an ongoing slight chance of further enhancement due to any significant flares from the sunspots on, or moving into the western hemisphere through the period, most likely from AR3380.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	40	15	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES16 >10MeV, >50 MeV and >100 MeV Protons



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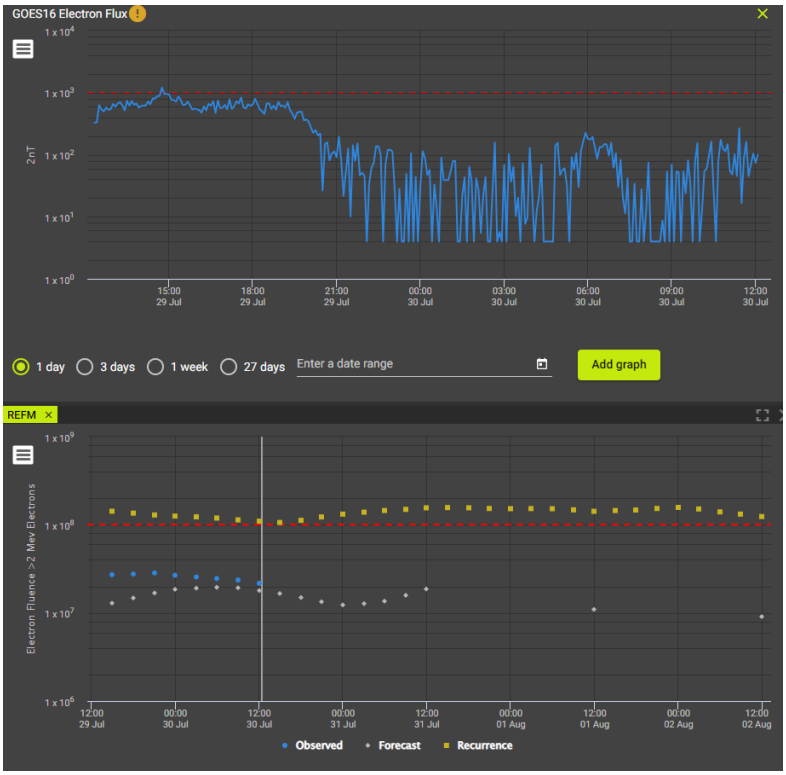
High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux has dropped to mainly background in response to the increased solar wind pressure by the current fast wind onset on day 1 (30 Jul). As this eases, there is a chance of flux rising to Moderate, perhaps briefly High (above 1000 pfu) later day 1 or day 2 (30-31 Jul), before a further drop out in observed flux likely occurs with any CME arrival on day 3 (01 Aug). Flux then rising again day 4 (02 Aug) to Moderate, with a slight chance of reaching High.

Despite periods of Moderate to High flux the associated 24 hour fluence is expected to remain below the Active (1e8 total pfu) threshold throughout. The main chances of approaching this level will be late day 2 or early day 3, before the arrival of any CME due to any increased flux from the current coronal hole enhancement. This does not feature in current REFM, which is likely to be providing poor guidance by day 2 (31 Jul).

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES-16 >2MeV Electron Flux and Fluence with REFM and Persistence.



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